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THESIS

A MICROCOMPUTER PROGRAM PACKAGE
OF THE
USAF STABILITY AND CONTROL DATCOM

by

John Randolph McGowan

June 1983

Thesis Advisor M.D. Hewett

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A Microcomputer Program Package
# of the
USAF STABILITY AND CONTROL DATCOM

by

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Submitted in partial fullfillment of the
requirements for the degree of

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I. INTRODUCTION

The advancement of microcomputer technology over the past few years has enabled the user to break away from large mainframe computer systems for the execution of numerous small application programs. Significantly large data base and complex programs have essentially remained intact on the mainframes due to the slow execution speed and available memory limitations imposed on the micros. Provided execution speed is not an important factor and judicious use of program memory space can be maintained, relatively large application and data base programs can be executed on a micro interfaced with additional disk drive storage capabilities.

The practicing engineer, undergraduate, and graduate students of the Aerospace field have at their disposal a wealth of application programs for the estimation of aircraft stability and control derivatives residing in numerous mainframe systems. These programs are usually complex, not "user friendly", require considerable time and effort to learn, and are not easily modified or integrated. However, essentially all have referenced the USAF STABILITY AND CONTROL DATCOM [REF. 1].

The DATCOM, in its entirety, is not capable of being programmed on a microcomputer due to memory constraints.

The DATCOM is, however, subdivided into numerous sections and, with proper programming techniques, these sections may be programmed and integrated to provide a user friendly and viable package encompassing the entire DATCOM.

Numerous references to the DATCOM follow and it is assumed that the reader is throughly familiar with this seven (7) volume document. In addition, for a thorough understanding of the programs and programming procedures discussed in this writing, the reader should have at hand a copy of the DATCOM for ready reference.

Over fifteen (15) DATCOM sections, have been programmed to date. The inclusion of these program listings have purposely been excluded for duplication cost considerations. Software copies and/or program listings of these programs may be obtained from the Aeronautical Engineering Department, Naval Postgraduate School.

A. MICROCOMPUTER SYSTEM CONSIDERATIONS

The programs described herein were written on an APPLE II PLUS personal computer with 48K of user RAM, two (2) five and one-quarter (5 1/4) inch disk drives, and an eighty (80) column dot matrix parallel printer. The APPLE Disk Operating System Version 3.3 (DOS 3.3) was also utilized for all Disk I/O Routines. With DOS 3.3 fully installed, approximately 36K of program space is available in RAM. therefore, caution should be exercised if any program is

rewritten for smaller RAM based machines or modifications to existing programs are made such that an increase in program size results.

Extensive data files are generated during program executions, therefore, two disk drives are a necessity.

For optimal program use, an 80 column printer is highly recommended for hardcopy data output.

B. PROGRAMMING LANGUAGE CONSIDERATIONS

APPLESOFT BASIC was utilized for all programming. The use of routines peculiar to APPLESOFT and the APPLE computer itself were kept at an absolute minimum to facilitate transformation of the programs into other machine Disk Operating Systems and/or BASIC languages.

The programs were written in BASIC for several reasons. BASIC, whether written on the APPLE or other popular home microcomputer, is easily convertable from one version to another. It is also easily modified, simple to use and is available as the primary language on virtually all popular microcomputers.

C. PROGRAMMING CONSIDERATIONS

A primary goal set at the outset of program development was to maintain user friendliness in all programs. User friendly, as defined herein, is an interaction between the user and the program such that the user is not burdened with

unnecessary data formatting, repeated reference to a complicated user's manual, or the inability to review and/or change input data. In addition, a user friendly program should be menu driven, and contain error handling routines which inform the user of the exact nature of the input error and prevent unacceptable entries.

A second consideration was execution speed. APPLESOFT and most other Micro Basics are interpreted languages. As such, they are inherently slow. Although compilers are available, they were not used since a compiled Basic program is difficult to modify. Instead, several programming schemes were utilized to increase execution speed which, in most cases, also decreased program size. All remark statements were excluded, all subroutines were placed at the beginning of the program file, multiple statements per line were implemented, and extensive use of data arrays were utilized.

II. PROGRAM DESIGN FEATURES

A. COMPATIBILITY WITH DATCOM

The general notation of the DATCOM has been completely preserved in all the programs. All variables, constants, and definitions presented in SECTION 2.1 of the DATCOM are similarly defined in the programs. Thus, the user has full reference to the meaning of any requested inputs and generated data.

The various sections of the DATCOM are numbered with a decimal system scheme as described in SECTION 1 and presented in the TABLE OF CONTENTS of that document. Similarly, each program file title is co-incident with its DATCOM counter-part. For example, to determine the Lift Curve Slope of a wing planform, the engineer would reference and follow the solution procedures outlined in SECTION 4.1.3.2 of the DATCOM. Whereas, the program user would select/run the program titled SEC.4.1.3.2 when presented with the MAIN PROGRAM SELECTION MENU.

All limitations imposed by the DATCOM are likewise imposed during program execution with one exception. The user is informed if he has exceeded DATCOM limitations and may select to rerun the program, alter his inputs, or override the warning.

Although each DATCOM section is self sufficient, data generated in one section often is required for solution in another. This requires the DATCOM user to record an inordinate amount of interim data to arrive at a specific solution in most cases. The program user, however, has an option of preserving all generated data on a storage data diskette for retrieval when required by another DATCOM section. The user is never required to record any data by hand.

B. PROGRAM MENU OPTIONS

The user is always presented with an options menu to select a course of action. The use of menus enables the user to quickly arrive at a specific program or program section for solution of a problem and subsequently jump to another area of concern with a single keyboard entry.

In addition to the MAIN PROGRAM SELECTION MENU, there are three (3) other basic menu types encountered within the programs. These include 1) the MAIN PROGRAM MENU, which directs the user to various sub-section menus, 2) the sub-section menus, which are encountered in the main program and usually concern data input and solution options, and 3) the DATA OUTPUT MENU, which provides the user with screen or printer output of current data and/or previously stored disk data. The DATA OUTPUT MENU also provides for options to save the current data to disk.

All menus provide return features so the user may scroll forward or back through the program and included menus.

C. USE AS A DESIGN TOOL

A primary purpose of the DATCOM is to systematically estimate basic stability and control derivatives by orderly applying the methodology of its individual sections to a given set of preliminary design criteria (i.e. flight condition and configuration data). Each section builds a data base of variables which are frequently referenced in subsequent sections. As such, the computer programs are similarly designed. If a total preliminary aircraft design is desired, the user has the option of integrating each program and its generated data by placing the programs in a DESIGN MODE. Consequently, each program is flagged to operate only on a specified data disk (DESIGN DATA DISK) identified by the user. Program generated data may then only be saved to this DESIGN DATA DISK. In addition, when previously computed data is needed within a program, it may only be retrieved and utilized for the particular design specified by the DESIGN DATA DISK. For example, SECTION 7.4.4.1 of the DATCOM outlines the methodology to compute the wing-body-tail acceleration derivative. Reference to this section reveals that eight (8) quantities computed from eight (8) different DATCOM sections are required for solution. When in the DESIGN MODE, these eight (8) terms,

previously identified and stored on the DESIGN DATA DISK, are automatically retrieved for use. The user does not have to rerun previous programs or reference the DATCOM.

III. PROGRAM LIMITATIONS

Time constraints and the enormity of the DATCOM itself (over 250 sections) have precluded its entire programming during this work.

At this time, only those sections of the DATCOM applicable to the solution of the longitudinal stability and control derivatives for conventional, straight-tapered wing planform configurations, attached to bodies with elliptical cross-sections, have been programmed. In addition, only subsonic flight regimes were considered. The inclusion of additional flight regimes (Transonic, Supersonic, and Hypersonic), various planform configurations (Double-Delta, Cranked), and additional DATCOM sections (e.g. solution for lateral-directional derivatives) is straight forward with the modular, menu-driven design of the existing programs.

Accuracy of program generated data was never found to exceed +5% of DATCOM values. Extensive effort was devoted in curve fitting required DATCOM graphical and tabular data to reach a required and accurate solution. In addition, all required analytical equations utilized by the DATCOM were replicated in the programs. Significant deviations in computed data result only if the user overrides a program generated warning that he has exceeded DATCOM limitations during data input.

IV. GENERAL SYSTEM DESIGN

The use of the DATCOM programs will require two (2) disk drives. Drive 1 is used as the source drive for the Master Program Disk. The Master Program Disk contains all the DATCOM program files in its directory. In addition, several other files unrelated to DATCOM are cataloged here. These files are used within other programs for system initialization, file creation, etc.

When the Master Program Disk is booted, the MAIN PROGRAM SELECTION MENU is presented. It is from this menu that all other options follow. The first option presented is INITIALIZE DATA DISK. Before any program is selected from the MAIN PROGRAM SELECTION MENU, an initialized data disk must be in Drive 2.

Selection of INITIALIZE DATA DISK enables the user to format a blank diskette either as a GENERAL DATA DISK or as a DESIGN DATA DISK. Data from one GENERAL DATA DISK may be transferred to another, deleted, or changed whereas DESIGN DATA DISKS are specifically designed for a preliminary design analysis and are coded as such. Each program will check the status code of the type disk in Drive 2 and will function accordingly, therefore, the user must be aware of the status of his data disk. Changes to data on the DESIGN

DATA DISK is not recommended as invalid design outputs will likely result.

The second option presented on the MAIN PROGRAM SELECTION MENU is ENTER DESIGN MODE. If the DESIGN MODE is selected, the user is reminded to ensure that an initialized DESIGN DATA DISK is in Drive 2 before continuation. If the DESIGN DATA DISK is in Drive 2, the user is then presented with the selection menu of all the available DATCOM programs. If the DESIGN MODE is not selected, a check is made by the program to ensure a GENERAL DATA DISK is in Drive 2, followed by the presentation of the selection menu of available programs.

If the DESIGN MODE is selected, the user may not arbitrarily interchange DESIGN DATA DISKS unless they have the same code. It is not recommended that identical codes be assigned for different designs, as inadvertent intermixing of data may occur. Backup copies of DESIGN DATA DISKS may be made to preserve all data and codes. Note: The code referred to above is nothing more than utilizing the volume option of APPLE'S Disk Operating System as described in [REF. 2].

V. GENERAL PROGRAM DESIGN

Each DATCOM program was structured to facilitate modifications and future additions. A top-down program structure resulted with eight (8) major program sections.

A. PROGRAM STATUS SECTION

On initial system boot or when the MAIN PROGRAM SELECTION MENU is selected, the user is presented the option of entering the DESIGN MODE. If selected, the user is prompted for a three digit code between 0 and 254 identifing the particular DESIGN DATA DISK in Drive 2. Upon input of this code, the program checks to insure that the designated Design Data Disk is in Drive 2, and, if there, this code is written to the Master Program Disk for additional checks by each DATCOM program. If the designated DESIGN DATA DISK is not found in Drive 2, the user is instructed to insert the proper disk prior to program continuation. The process is repeated until the codes agree or the user terminates the program.

Thereafter, when a DATCOM program is selected from the MAIN PROGRAM SELECTION MENU, and the user is in the DESIGN MODE, the program status section of each selected DATCOM program checks the DESIGN DATA DISK code stored on the Master Program Disk against that of the DESIGN DATA DISK in

Drive 2. A match of codes permit execution of the program. A mismatch halts execution until the user either provides the correct Design Data Disk to the system or terminates the program. This is a safety feature incorporated to prevent inadvertent inclusion of unwanted data to a particular preliminary design. The program status section also flags the program to by-pass certain user inputs that have previously been entered or computed while in the DESIGN MODE.

If the user is not in the DESIGN MODE, the program status section only verifies that a DESIGN DATA DISK is NOT in Drive 2 and flags the program to request user inputs from the keyboard or from the GENERAL DATA DISK in Drive 2.

B. PROGRAM CONSTANTS SECTION

This section does nothing more than equate specific variables to numeric values for use within the program, i.e. PI = 3.1415926, g = 32.1741, etc.

C. ARRAY DEFINITION SECTION

String arrays are dimensionalized and filled within this section from string variable data included in the Data Statements at the end of the program. Numeric arrays are dimensionized but assignment of array data is usually a result of program generated data, inputs from the user, or disk stored data within the Main Program Section.

D. SUBROUTINE SECTION

This section of the program contains all subroutines used throughout the program. Subroutines encountered may include curve-fitting routines, keyboard fetches, Disk I/O schemes, and numerous user prompts. Repetitive simple DATCOM analyitical equations are sometimes included.

E. MAIN PROGRAM MENU

The MAIN PROGRAM MENU is the starting point for all options within the program. Options included in all programs include provisions to return to the MAIN PROGRAM SELECTION MENU, select the DATA OUTPUT MENU, and begin or end the program.

Specific menu options may include input choices for various planforms (foreward, aft, vertical), solution options, etc. All selections from the MAIN PROGRAM MENU require only a single keyboard entry.

F. MAIN PROGRAM SECTION

This section of the program requests data inputs from the user, performs all the major program calculations, and provides error checking. Sub-menus may be incorporated dependant on the computational schemes and data input requirements of the program. In most cases, however, the

program will fall through to the DATA OUTPUT MENU when calculation and/or data input is complete.

G. DATA OUTPUT MENU

The DATA OUTPUT MENU provides the user with I/O options for both program generated and stored disk data. All Data (program generated or disk) may be routed for output to either the CRT or printer, while current program generated data may also be saved to the data disk. Attempts to save data to a disk file which contains data from a previous program run will result in a warning message prompt informing the user that the data file already contains data. The user then has the option of replacing this file data.

H. DATA OUTPUT SECTION

All disk, screen, and printer I/O routines are listed in this program section. Numerous program commands are peculier to APPLESOFT BASIC and DOS 3.3. [REFS. 2 and 3] provide an excellant source of reference for modifications to this portion of the program.

I. DATA SECTION

String and numeric array data is defined in Data Statements within this section. The string data is usually in the form of variable data definitions, i.e. "LIFT CURVE SLOPE = ", and will be assigned to a string array, i.e. as

D$(6), the sixth element of array D$. Generated program data, if assigned to an array, will usually correspond to its string variable array counterpart. For instance, D(6), the sixth numeric element of array D may be the computed numeric value of the LIFT CURVE SLOPE, i.e. 6.28. Therefore, the program statement "100 Print D$(6);D(6)" would, when executed, output "LIFT CURVE SLOPE = 6.28".

Numeric array data found in this section usually corresponds to constants for polynomial curve fitting routines.

VI. RESULTS

The DATCOM is divided into nine (9) major section classifications, which are further sub-divided into 184 sections relative to a single specific item, e.g. wing zero lift angle of attack. Each of these single sections usually provide two solution methods for each of the following flight regimes: 1) subsonic, 2) transonic, 3) supersonic, and 4) hypersonic.

This work, in addition to five (5) supportive programs, consists of twenty (20) programs corresponding to the twenty (20) DATCOM sections necessary to compute an aircraft's longitudinal stability and control derivatives in subsonic flight. The particular solution method used was dependent primarily on planform geometry (straight-tapered), body cross-section (elliptical), flight regime (subsonic) and ease of programming. These twenty-five (25) programs occupy 482 of 496 available disk sectors (256 bytes per sector) of a DOS 3.3 formatted disk (DOS 3.3 occupies 64 of the 560 total disk sectors).

Compression of the programs by using a pseudo-compiler such as COMPRESS [Ref. 4] will reduce the disk storage requirements to approximately 400 sectors. This will result in an average of 16 sectors of storage allocation per program (or per DATCOM section). Assuming that each program

would double in size to accommodate the inclusion of the additional flight regimes and alternate solution method, it would require twelve (12) disks for storage of 184 DATCOM section programs.

VII. CONCLUSIONS

A large, complex programming attempt, such as programming the DATCOM, is no longer restricted to a mainframe computer system.

This microcomputer based version of the DATCOM provides an ideal and inexpensive teaching tool for students and educators at both the graduate and undergraduate levels. In addition, this relatively fast, low cost alternative for preliminary design may also be used advantageously throughout industry. The aircraft manufacturer will not have to tie up a mainframe, where access time may be at a premium, for design studies which require multiple DATCOM related solutions. Several engineers, each with their own office microcomputer, may simultaneously be working on a preliminary design of different flight conditions and configurations, at a fraction of the cost of using a mainframe.

VIII. RECOMMENDATIONS

All the programs to date have not been subjected to heavy use by inexperienced users. It is this test which will bring to light any "bugs" that may reside in the programs. "Bug proof" computer programs are usually a result of a refinement process. As such, and as much as this author would like to admit otherwise, the programs should be evaluated for errors by inexperienced users.

As each program was written, programming techniques developed in previous programs were often refined for implementation. Consequently, later programs became more efficient, compact, and otherwise aesthetically more attractive in overall program design. The earlier programs should be rewritten to accommodate these changes.

The average program size (approximately 6K) is relatively small compared to the 32K of RAM available to the user. This was deliberate, to allow for the addition of different solution methods and/or flight regimes. This is, however, an inefficient use of disk space since the existing programs utilize numerous common routines. If additional DATCOM sections are similarly programmed (one solution method, subsonic case, etc.) combining the programs (several DATCOM sections) to achieve lengths of approximately 30K is therefore recommended. In addition, the use of DOS EXEC

routines, as described in [Ref. 2] could also be utilized and should be highly considered. In either case, substantial disk space could be saved (up to 40% in some cases).

Continued work on this effort should result in an excellent software package for use throughout the Aerospace field.

APPENDIX A

DATCOM PROGRAM USERS GUIDE

A. MINIMUM SYSTEM REQUIREMENTS

The minimum system requirements necessary to run the DATCOM programs on the MASTER PROGRAM DISK are as follows:

APPLE II PLUS with 48K RAM
APPLE DOS 3.3 Disk Operating System
Two (2) 5 1/4, 35 Track, Disk Drives

The use of an 80 column parallel printer is highly recommended for hardcopy outputs. The above system should also be configured such that the disk drive interface and the parallel printer interface cards are located in Slots 6 and 1 of the APPLE II Motherboard, respectively.

B. INITIALIZATION OF DATA DISKS

Prior to executing any program on the Master Program Disk, an Initialized Data Disk must be in Drive 2.

There are two types of Data Disks. One, a GENERAL DATA DISK, is used for the storage of disk data from various DATCOM program runs where the preservation and/or integration of data is not required. This disk should only be used for general application purposes. The second type of Data Disk is the DESIGN DATA DISK. This disk is used exclusively to determine the aircraft Wing-Body-Tail

stability and control derivatives during preliminary design analysis for various flight conditions and aircraft configurations. The user is urged to initialize several diskettes of each type for ready use.

To initialize a Data Disk:

1. Place the MASTER PROGRAM DISK in Drive 1 and a blank disk in Drive 2.

2. Boot the System. The following options will be displayed on the CRT:

```
***************************************
*                                     *
*     MAIN PROGRAM SELECTION MENU     *
*                                     *
*      1. INITIALIZE DATA DISK        *
*      2. ENTER DESIGN MODE           *
*      3. SELECT DATCOM PROGRAMS      *
*      4. END                         *
*                                     *
*         INPUT SELECTION...?         *
*                                     *
***************************************
```

3. Depress the (1) key. The following will appear:

```
***************************************
*                                     *
*         INITIALIZATION MENU         *
*                                     *
*   1. INITIALIZE DESIGN DATA DISK    *
*   2. INITIALIZE GENERAL DATA DISK   *
*   3. RETURN TO MASTER MENU          *
*                                     *
*      INPUT SELECTION...?            *
*                                     *
***************************************
```

4. Selection of option (1) will result in the following prompt:

```
***************************************
*                                     *
*   INSERT A BLANK DISK IN DRIVE 2    *
*                                     *
*   INPUT 3 DIGIT CODE NUMBER....?    *
*                                     *
***************************************
```

5. Enter a number between 0 and 254 to identify this disk as a DESIGN DATA DISK and hit the return key. At this point, DO NOT hit any key or secure power to the system until the Disk Drive in-use lights are extinguished and the Initialization Menu is again displayed. This process may be repeated for additional initialization of DESIGN DATA DISKS.

The proceedure for initialization of a GENERAL DATA DISK is similar except that the request prompt for the code number will not be given. To return to the MAIN PROGRAM SELECTION MENU key option (3) from the Initialization Menu.

C. GENERAL DATCOM PROGRAM USE

1. Place the MAIN PROGRAM DISK in Drive 1 and a GENERAL DATA DISK in Drive 2.

2. Boot the system.

3. Select option (3) from the Master Program Selection Menu and a menu of all available programs on the MASTER PROGRAM DISK will be displayed. Enter the appropriate number and the desired program will execute.

If a GENERAL DATA DISK is not in Drive 2, the user will be unable to continue past the Master Program Selection Menu until a GENERAL DATA DISK is detected in Drive 2.

D. DESIGN MODE

1. Place the MASTER PROGRAM DISK in Drive 1 and a DESIGN DATA DISK in Drive 2.

2. Boot the system.

3. When the Main Program Selection Menu appears select the ENTER DESIGN MODE option. The following prompt will appear:

```
****************************************
*                                      *
*  INPUT DESIGN DATA DISK CODE NUMBER  *
*                                      *
****************************************
```

4. Input the identifying code of the particular DESIGN DATA DISK. If the entered code does not match that of the disk in Drive 2, the following prompt will appear:

```
***************************************
*                                     *
*           CODE MISMATCH             *
*         UNABLE TO CONTINUE          *
*                                     *
*            PRESS ANY KEY            *
*                                     *
***************************************
```

After a key is depressed, the user is returned to the Main Program Selection Menu.

If the codes match, the user is returned to the Main Program Selection Menu immediately after code entry. Option (3), SELECT DATCOM PROGRAMS, may now be entered to list the available DATCOM programs for execution.

E. HINTS AND TIPS

1. Externally label Data Disks as to their type (GENERAL or DESIGN) and, in the case of the DESIGN DATA DISK, also include the code number and some form of design criteria, (e.g. cruise, mach .5, 40000 ft.).

2. Back up both the MASTER PROGRAM DISK and the Data Disks using a copy program such as COPYA found on the APPLE DOS 3.3 SYSTEM MASTER DISK.

3. Use a back-up MASTER PROGRAM DISK, not the original.

4. Do not delete files on either the Master Program Disk or the Data Disks.

5. Never reset or secure power to the computer when the drive in-use lights are on.

6. When in the DESIGN MODE, sequentially run through the DATCOM programs. Preliminary design data builds upon itself such that data may be required from previous programs.

7. Review each DATCOM section before running its program counterpart.

APPENDIX B

EXAMPLE PROGRAM USE

Provided the system is properly set up as described in APPENDIX A (PROGRAM USERS GUIDE) and option (3) (SELECT DATCOM PROGRAM) has been selected from the MAIN PROGRAM SELECTION MENU, the user will be presented with a menu of the available programs on the MASTER PROGRAM DISK. Single key selection of any program will dictate a run; however, since the programs frequently utilize data from previous program runs, it is recommended that the user sequentially execute the individual programs. This is especially true when in the DESIGN MODE. The user will also note that all available numbered programs are titled in accordance with their DATCOM counterparts except, (1) - FLT.DATA.

FLT.DATA provides all the DATCOM programs specific data reguarding a particular user defined flight regime. This data includes Mach number, density ratio at altitude (based on ICAO standard atmosphere), etc. To avoid numerous repetative inputs in the DATCOM programs for this type of data, FLT.COND should be run first and is presented below to familiarize the user with a general approach to the use of this and all other DATCOM programs.

A. To run FLT.DATA, input (1) when presented with the menu of programs on the MASTER PROGRAM DISK. The FLT.COND. MAIN PROGRAM MENU will appear as follows on the CRT:

```
****************************************************
*                                                  *
*                   FLIGHT DATA                    *
*                                                  *
*  MAIN PROGRAM MENU:                              *
*                                                  *
*  1. BEGIN PROGRAM                                *
*  2. DATA OUTPUT MENU                             *
*  3. RETURN TO MAIN PROGRAM SELECTION MENU        *
*  4. END                                          *
*                                                  *
*  INPUT SELECTION                                 *
*                                                  *
****************************************************
```

B. Selection of (4) will simply end the program. An input of (3) will result in a return to the MAIN PROGRAM SELECTION MENU; whereas, (2) will jump the program to the DATA OUTPUT MENU. Inputting (1) will result in two user input requests:

```
*****************************************
*                                       *
*  INPUT GEOMETRIC ALTITUDE..(FT)  ?    *
*                                       *
*****************************************
```

As an example, enter 20000 and press the return key.

```
******************************
*                            *
*   INPUT TAS..(FT/SEC)  ?   *
*                            *
******************************
```

Next, input 300 and press return.

```
*******************
*                 *
*   WORKING....   *
*                 *
*******************
```

The "WORKING" prompt will be briefly displayed while computations are being made for a true airspeed of 300 ft/sec at 20000 ft. When data is computed, the DATA OUTPUT MENU will appear.

```
**********************************************
*                                            *
*   DATA OUTPUT MENU:                        *
*                                            *
*   1. OUTPUT CURRENT VALUES TO SCREEN       *
*   2. OUTPUT CURRENT VALUES TO PRINTER      *
*   3. SAVE CURRENT VALUES TO DISK           *
*   4. DISK DATA TO SCREEN                   *
*   5. DISK DATA TO PRINTER                  *
*   6. RETURN TO MAIN PROGRAM MENU           *
*   7. END PROGRAM                           *
*                                            *
*   INPUT SELECTION                          *
*                                            *
**********************************************
```

C. Selection of (1) in the DATA OUTPUT MENU will display current data on the CRT; whereas, (2) will result in a hardcopy output. For this example, input (2).

As shown below, from the user inputs of altitude and true airspeed, considerable data has been generated. To preserve this data, input (3) and the values will be saved to the data disk in drive 2. If data already exists on the disk

from a previous run of this program, the user will be given the option of replacing the existing disk data with that just computed. In either case, a return to the DATA OUTPUT MENU will ensue.

```
GEOMETRIC ALT...(FT) = 20000
GEOPOTENTIAL ALT...(FT) = 19980.8388
TAS...(FT/SEC) = 300
MACH NO. =.289316665
G...(FT/SEC 2) = 32.1124801
TEMP...(DEG. R) = 447.433132
TEMP. RATIO = .86262499
PRESS...(PSF) = 973.269256
PRESS. RATIO = .459909961
DENSITY...(SLUGS/FT 3) = 1.26725916E-03
DENSITY RATIO = .533151796
ABSOLUTE VISCOSITY...(LB-SEC/FT 2) = 3.33159168E-07
KINEMATIC VISCOSITY...(FT 2/SEC) = 2.62897423E-04
REYNOLDS NO./X...(PER FT) = 1141129.48
```

D. All the DATCOM PROGRAMS are similarly designed such that the user is prompted for inputs and presented with various option menus. These prompts and menus are usually self explanatory and in those cases where ambiguity exists, the user is referred to a specific section of the DATCOM via program prompt for clarification.

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6. Roskam, J., *Methods for Estimating Stability and Control Derivatives of Conventional Subsonic Airplanes*, published by the author, 519 Boulder, Lawrence, Kansas, 1971.

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